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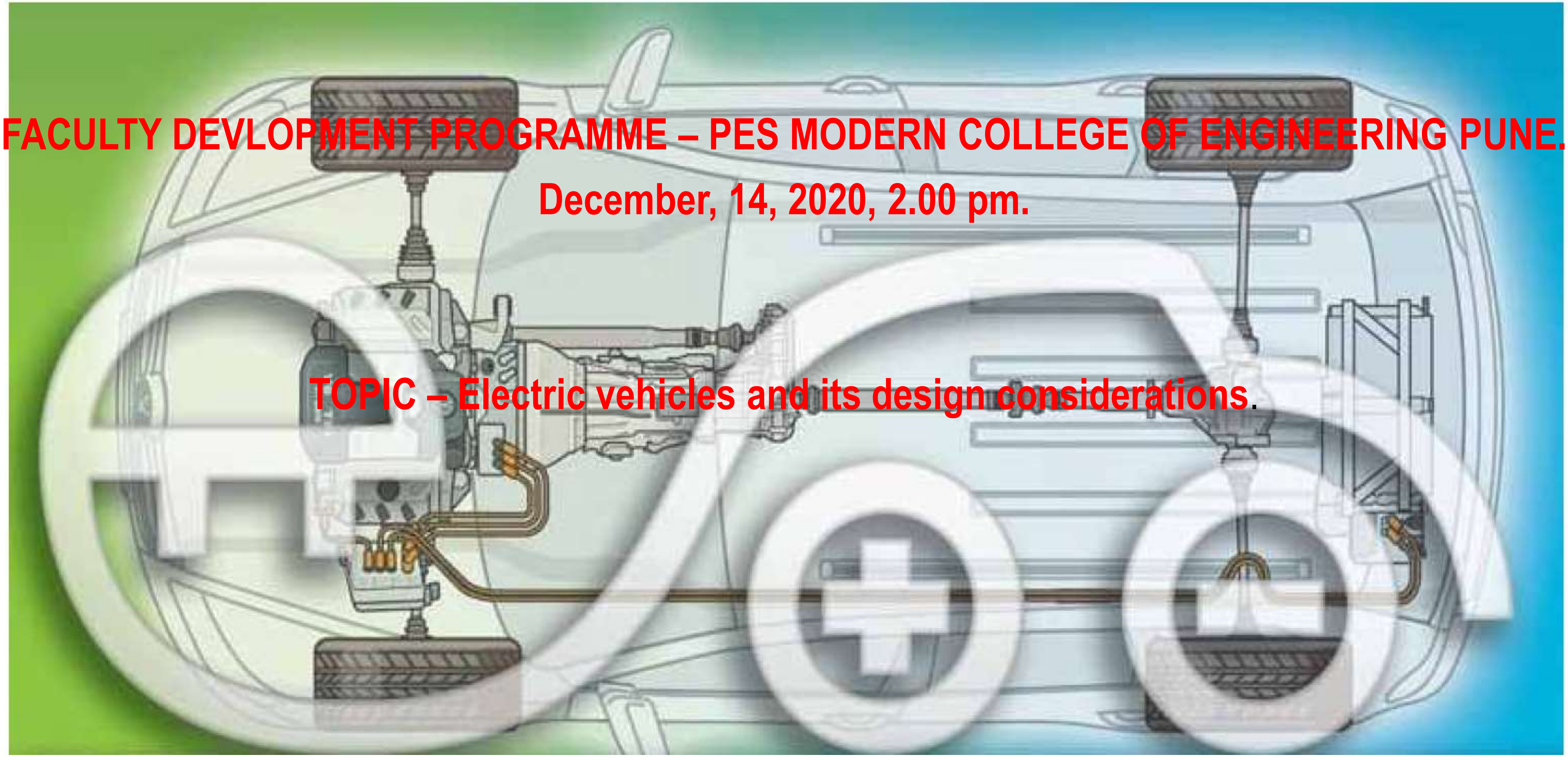

FACULTY DEVLOPMENT PROGRAMME – PES MODERN COLLEGE OF ENGINEERING PUNE.

December, 14, 2020, 2.00 pm.

TOPIC – Electric vehicles and its design considerations.

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WHY ELECTRIC VEHICLE?

The Indian auto industry is one of the largest in the world which accounts for 7.1% of the country's Gross Domestic Product (GDP). Production of passenger vehicles, commercial vehicles, three wheelers and two wheelers grew at 5.41% in FY17 to 25 million vehicles from 24 million vehicles in FY16.

Exhaustion of fossil fuels, environmental concerns and increase in energy costs is compelling India to shift to electric mobility. E-mobility is the future and the most potential solution.

Committing to the Paris Agreement, India has announced a major transformation to electric vehicles by 2030. The Government has also initiated Faster Adoption and Manufacturing of Hybrid and Electric vehicles (FAME) scheme which provides incentives for purchasing electric vehicles.

National Electric Mobility Mission Plan (NEMMP) 2020' which was formed in 2013 addresses issues of National energy security, vehicular pollution and growth of domestic manufacturing capabilities.

Government's vision is to see six million electric and hybrid vehicles by 2020.

Unlike vehicles with ICE, electric vehicles do not produce exhaust gases during operation. This alone makes electric vehicles more environmentally friendly than vehicles with conventional technology.

Here we will discuss about the vehicle driven by electric motor powered by re-chargeable batteries.

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- The Indian Automobile Industry is currently ranked 5th largest in the world and is set to be the 3rd largest by 2030.
- The Government has created a demand for EVs by buying in bulk, which could provide for large orders for automakers.
- The Indian EV Industry is in its nascent stages with only 2 electric car manufacturers.
- While there is a vision for 100% electric vehicles by 2030, most industry experts indicate that around 40-45% EV conversion by 2030 is a realistic expectation.
- India offers huge opportunities in the EV ecosystem. This is a market in developmental stages

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Current status of the Indian Auto Industry.

The automobile industry is divided in to main segments like

2/3 Wheelers,

Passenger cars,

commercials and tractors

The table here-below gives the OEM's and no of manufacturing plants segment wise –

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	Passenger vehicles	2 Wheeler	3 Wheeler	Commercial vehicles	Tractors
No. Of OEM's	15	13	7	12	17
No of mfg units	29	22	7	34	20
	Maruti Suzuki	Hero moto corp	TVS	Tata motors	Mahindra
	Hyundai	Honda motors	Bajaj	Ashok leyland	Escorts
	tata Motors	Bajaj	Piaggio	Force motors	Tafe
	Fiat	TVS	Atul Auto	Hindustan motors	John deere
	Ford	Suzukimotor cycles	Scooters India	Isuzu motors	New Holland tractors
	Honda	Yamaha	mahindra	Mahindra	International tractors
	General Motors	Mahindra	Force motors	AMW motors	Force motors
	mahindra	Royal-enfield		Piaggio vehicles	Indorama tractors
	Nissan	Piaggio		SML Isuzu Ltd	SAS Motors
	Toyota	LML		Eicher	HMT tractors
	Volkswagen	Harley Davidson		Volvo	CNH Industrial
	Renault	Triumph		man force	Ace tractors
	Premier auto	kawasaki			Preet tractors
	Mercedes benz				SAME DEUTZ FAHR INDIA
	BMW				Standard tractors
					Captain tractors
					Trishul tractors

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- Production of automobiles increased at a CAGR of around 4% over FY 12 to FY 2017, Commercial vehicles and 3 wheeler production witnessed negative growth.
- The industry accounts for 7.1% of country's GDP.
- India is also a prominent exporter and has strong export growth expectation for the near future.

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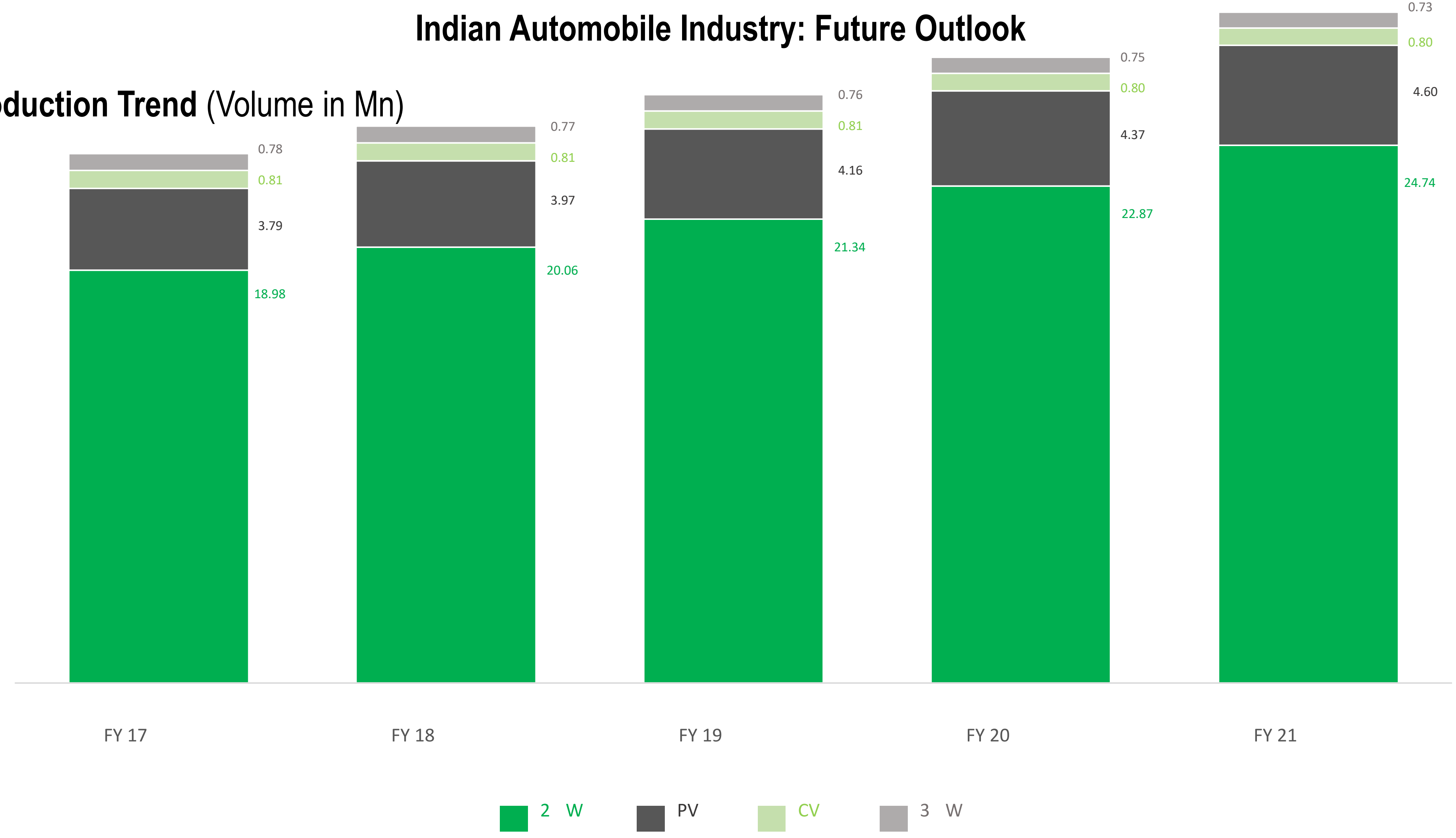
Indian Automobile Industry: Future Outlook

Vehicle Production Trend (Volume in Mn)



Source: SIAM data and Feedback Analysis

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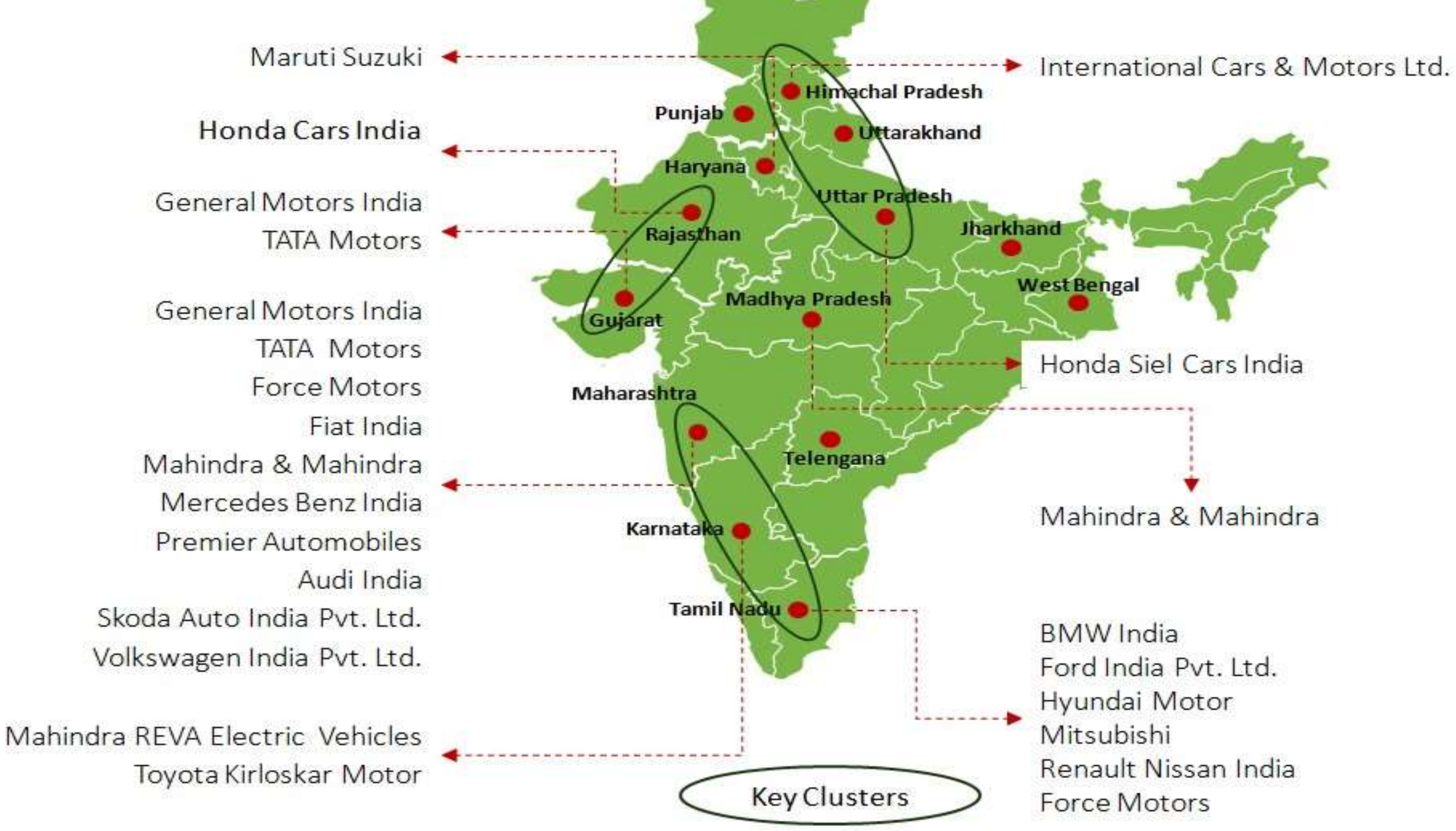
GEOGRAPHICAL PRESENCE OF PASSENGER VEHICLE OEM IN INDIA



EV _ Is it the answer?

EV solves two major issues – **Climate change and Energy Security**

Lowers overall energy consumption and emission regardless of source

Much lower in noise pollution

Use available power sources

Initial cost is high however, profitable in long run.

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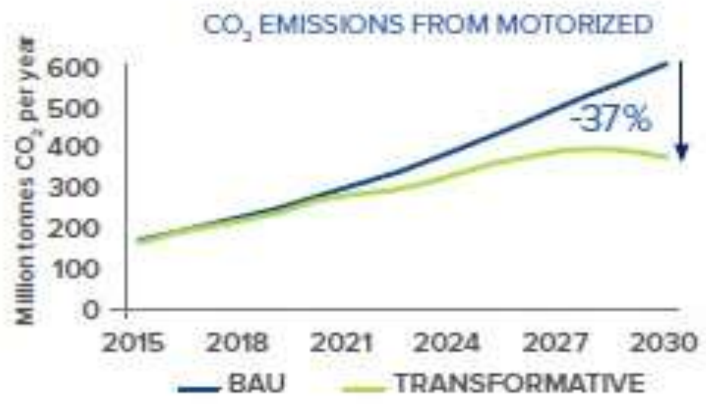
STRATEGIC IMPERATIVES TO LOOK AT Evs

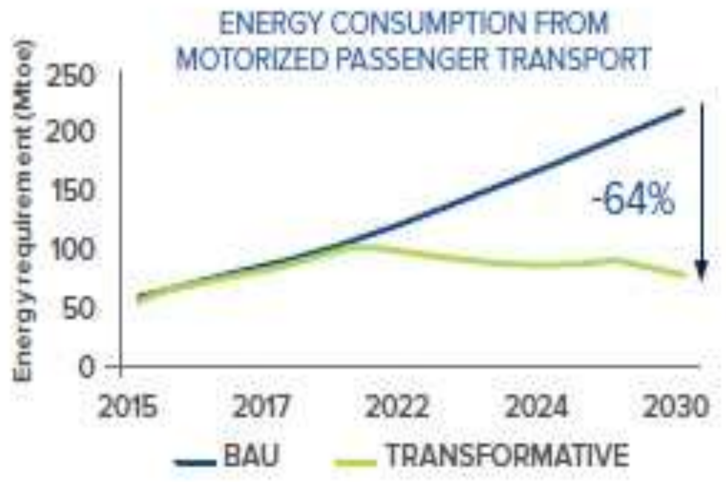
➢ Higher Carbon emission –

EVs could reduce CO_2 emission by about 37%



➢ Lower power demand –

Evs could help grid stability going forward by creating additional power demand.



➢ Fuel security risk –

Fuel bill of about US $ 60 Bn a year can be saved.

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E- mobility and its impact-India

Environment –

- Climate change
- Reduction of global CO 2
Emissions
- Reduction of Noise emission
- Awareness of consumption
Of raw materials.

Technology –

- Technical advantage of electric
Motor compared with IC engine.
- Increase in efficiency
- High voltage safety

Society -

Growing mobility
Increasing urbanization
Increasing acceptance
Increasing demand

Economy –

Limited Oil reserve
Rising prices for fossil fuels
Desire for independence from
oil exporting countries

Infrastructure -

Comprehensive infrastructure
to supply energy for EV

Policies --

International specifications for
emission limits.
Development plans and
subsidies.

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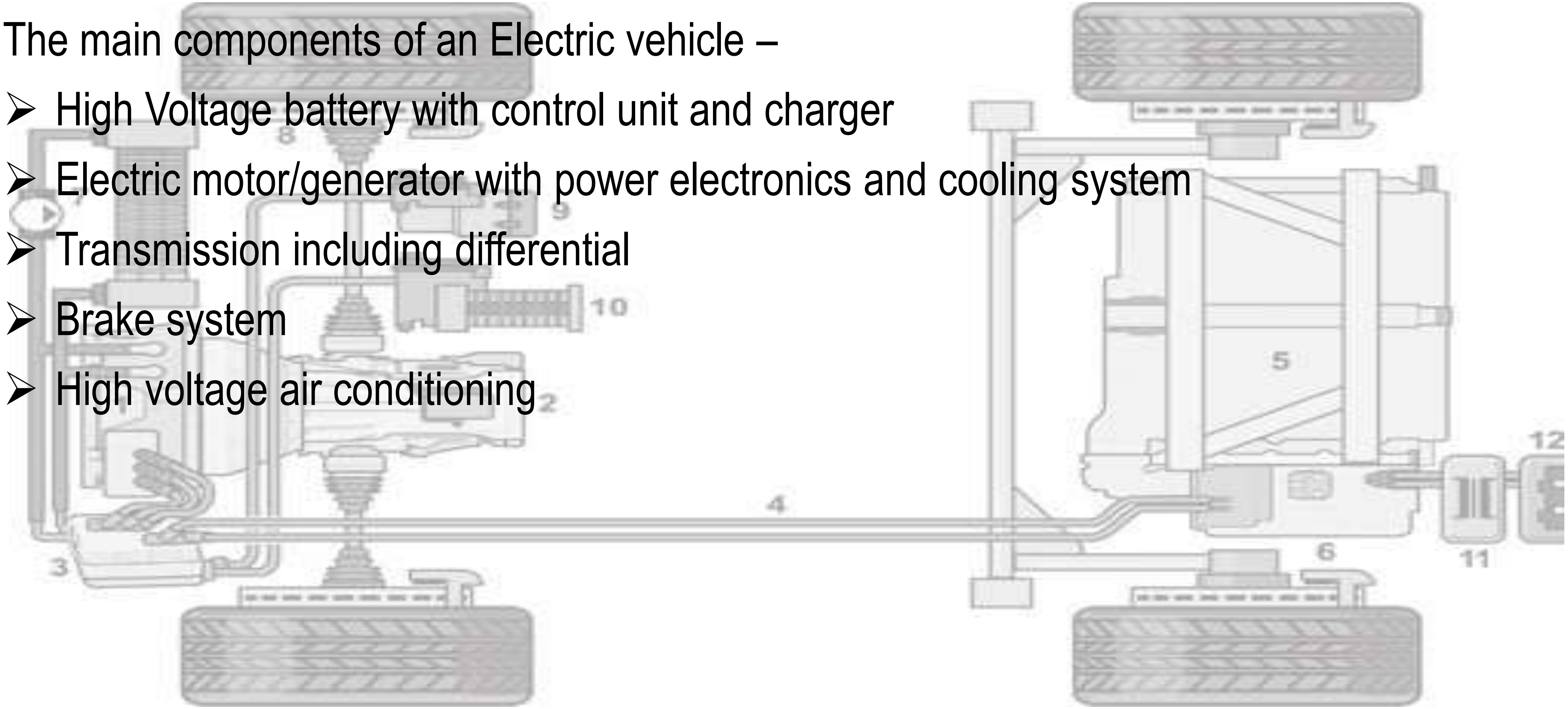
BASICS OF E-MOBILITY

The main components of an Electric vehicle –

- High Voltage battery with control unit and charger
- Electric motor/generator with power electronics and cooling system
- Transmission including differential
- Brake system
- High voltage air conditioning



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OVER VIEW OF POLITICAL STRUCTURE INVOLVED IN EV POLICY PLANNING

Prime Minister's Office

NITI Ayog*

Mandated to set out the Transformative Mobility Mission for India

- Ministry of Heavy Industries & Public Enterprises (Department of Heavy Industries)
- Ministry of power & Renewable Energy
- Ministry of urban Development
- Ministry of Finance
- Ministry of Roads & National High ways.
- Department of Science & Technology

National Electric Mobility Plan (NEMMP) 2020 targets to deploy 5 to 7 million electric vehicles in the country by 2020.

NEMMP also targets 400,000 passenger battery electric cars by 2020 avoiding 120 million barrels of oil and 4 million tons of CO_2. Total investment required is about RS 20,000 to 23,000 Crores (approximate 3 Billion US Dollars)

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Planned approach of mobility transformation.

Elements of India's Mobility transformation	OPPORTUNITY AREAS	NEW MOBILITY
System integration	Assembling the pieces ❖ Mobility as a service ❖ Interoperable transport data	SHARED
Shared infrastructure development	Building the eco system ❖ Mobility oriented development ❖ Vehicle grid integration	ELECTRIC
Scaled manufacturing	Creating the supply ❖ Product manufacturing ❖ Electric vehicle deployment	CONNECTED

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Push towards EV inevitable in India.

The government is firmly disposed towards bringing in low/reduced carbon footprint in India’s mobility scenario by 2030, and EV seems to be the PIVOTAL.

Government is seriously discussing and working on push towards EV, alternate fuels and move towards ‘shared mobility’.

Public transport (Bus & Fleet cars) and 2/3 wheelers are the first movers towards EV in India.

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TOWARDS EV MISSION 2030.

Currently Electric car market is at a very early stage with only 2 serious players, recently Hyundai also has joined in the movement, where as other's are likely to come in soon, and some of the manufacturer are servicing with hybrid cars from other countries.

The EV car market movement was started as early as 2001 in India by REVA (currently owned by Mahindra).

It took a long time to get acceptance to EV mainly due to the cost factor, range and the inadequate charging support.

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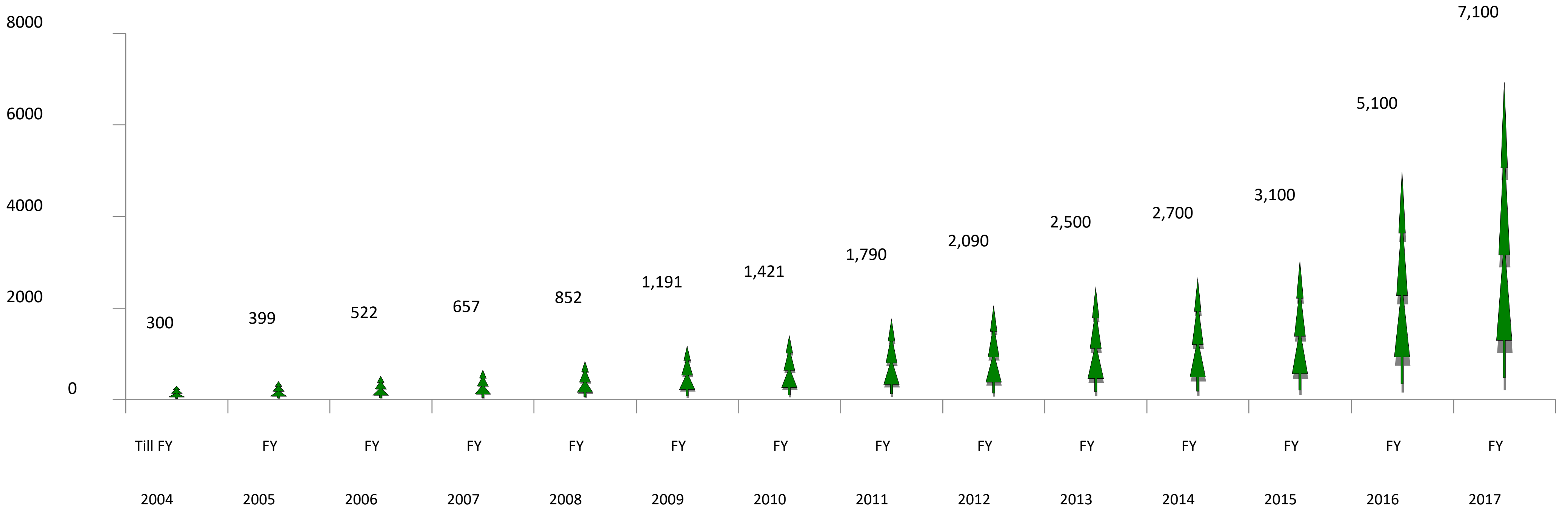

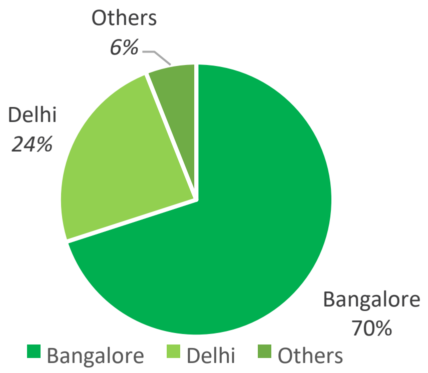

Source: Feedback Analysis

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Approach to Future EV Market Estimation.

Auto Industry body, SAIM had predicted the 2026 sales of vehicles in India based on average GDP growth of 5.8%

The future projections various types are as given here below –

2016-17 Revised classification as per NITI AYOG	2016-17 Domestic sales	2026 SIAM PROJECTIONS (Min.)	2026 SIAM Projections (Max.)	2026 SIAM Projections (Median)
Passenger Vehicles	2,132,709	5,170,000	7,370,000	6,270,000
Passenger vehicles – Commercial/Fleet	914,018	4,230,000	6,030,000	5,130,000
Commercial vehicles – Goods	616,106	1,700,000	3,315,000	2,507,500
Commercial vehicles - Passenger	98,126	300,000	585,000	442,500

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Three wheelers	511,658	120,000	1,500,000	1,350,000
Two wheelers	17,589,511	50,600,000	55,600,000	53,100,000
Total Vehicles	21,862,128	63,200,000	74,400,000	68,800,000

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Estimates based on NITI Ayog's plan.

These assumptions were taken in to consideration based on the vehicle type and the current ground realities.

2016-17 Revised classification as per NITI Ayog	2030 Business as Usual (BAS)	2030 Transformative	2026 Business as usual (BAU)	2026 Transformative
Passenger Vehicles _ Personal	1%	40%	0.5%	20%
Passenger vehicles _ Commercial / fleet	5%	100%	2.00 %	60%
Commercial vehicles_ Goods	0%	0%	0%	0%
Commercial vehicles_ Passenger	1%	100%	0.5%	60%
Three wheelers	5%	100%	2%	50%
Two wheelers	5%	40%	2%	20%

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Likely market of EV in India considering above 2 factors

	SIAM Data	Feed back estimate	Feedbacexplanatione arlierk projections	based on the
2016-17 revised classification as per NITI Ayog	2016-17 Domestic sales (All type)	2016-17 Domestic sales _EV only	2026 Business as usual	2026 Transformative
Passenger vehicles_Personal	2,132709	2,000	31,350	1,254,000
Passenger vehicles_commercial/fleet	914,018		102,600	3,078,000
Commercial vehicles_Goods	616,106			
Commercial vehicles_Passenger	98,126	20	2,213	265,500
Three wheeler	511,658	50	27,000	675,000
Two wheeler	17,589,511	22,000	1,062,000	10,620,000
Total	21,862,128	24,070	1,225,163	15,892,500

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EV CHARGERS.

Industry structure –

About 15 firms currently supply EV chargers in the country.

Only 3 firms are supplying 4 wheeler AC chargers, namely RRT Electro power, Chennai; Mass tech controls, Mumbai; and Exicom, New Delhi.

These are mostly power electronics companies & battery charger manufacturers who have diversified into EV chargers.

About 10-12 firms cater small 2 W AC chargers.

Global EV Chargers –

About 5-6 global firms are eyeing the EV chargers market closely and should enter very soon.

These firms have their own global designs and products and are studying the technical specifications, business models and potential for their products. These products although CE certified and working satisfactorily in Europe, need rework to give satisfactory performance in local conditions. All of them are targeting 4 wheeler's chargers mainly for passenger cars.

ABB has tied up with Ashok Leyland for DC Fast charging system for commercial bus, and the DC fast charger for passenger car is already installed in new Delhi.

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Indian firms in EV chargers –

Lot of local business houses are taking interest in the charging business, majority of them are in power electronics and battery rectifiers business currently.

Raychem RPG India, Analogic India, Deltron, EOS Power, Ador Powertron, Kraft power con are few names we will see in this business in near future.

Market Characteristics and Business Models –

EV charger market is at a very primary level for passenger car charging, where as the 2 wheeler chargers are manufactured locally.

Due to the limited scale of business, Charger market is currently limited to small firms.

The high technology product required for reliable operation and fast charging systems are now being looked for and many local as well international firms are getting ready design and products for Indian market.

Most of the chargers available currently in the country are slow chargers.

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Business model is mainly depending upon the OEM's for 2 wheeler, and for passenger cars and city buses the market is yet to open to public domain, currently this segment require a licence to operate and majority of the fleet owners have own facility.

Recently there are initiative to open up this business to private players also. The tenders are already floated for charging stations in different states. Currently these tenders are floated by government agencies, however the small players can also get entry.

Based on the NITI Ayog plan, the Ministry of Power has already undertaken several leads in pushing the EV Infrastructure initiatives though its various PSU companies.

NTPC will be a key player in setting up the EV chargers infra in the country.

Tata Power is a private power distribution company investing in to EV charging infrastructure. Tata has already installed 3 charging stations in Mumbai, planning for 50 no in Mumbai and new Delhi.

OLA has gone a step ahead in implementing charging stations. OLA has invested RS 50 Cr in the EV project, about 200 cars are charged in a pilot project at Nagpur.

Current installed no of EV chargers in India is about 270 units as at 2017 official figures.

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Likely future market for EV Chargers in India

	2017-18	2018-19	2019-21	2021-25	Cumulative potential upto 2026
No of EV Charging stations likely to be set up	1,000	5,000	50,000	350,000	406,000
Norms of EV Chargers likely to be installed	4	4	6	6	
Total EV Chargers likely to be installed	4,000	20,000	300,000	2,100,000	2,424,000
% of AC Slow chargers likely	90%	80%	80%	70%	
% of DC Fast Chargers likely	10%	20%	20%	30%	
No of AC Slow chargers likely to be installed	3,600	16,000	240,000	1,470,000	1,729,600
No of DC Fast Chargers likely to be installed	400	4,000	60,000	630,000	694,400

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OVER VIEW OF EV BATTERY MARKET IN INDIA.

Battery market currently ruled by Exide industries and Amara Raja Industries, mainly for Lead acid batteries, worth of RS 177 Billion, and around 80.5 Million units.

Automotive is a key large market accounting for 60% of the market in India.

India is a virgin market for Lithium Ion or other advanced batteries, recently in last couple of years the Lithium ion batteries packaging is started and the capacity is likely to be about 3 GW by 2020.

No of industry giants have plans to manufacture LI batteries locally under the 10 Giga projects – AATMA NIRBHARA BHARAT.

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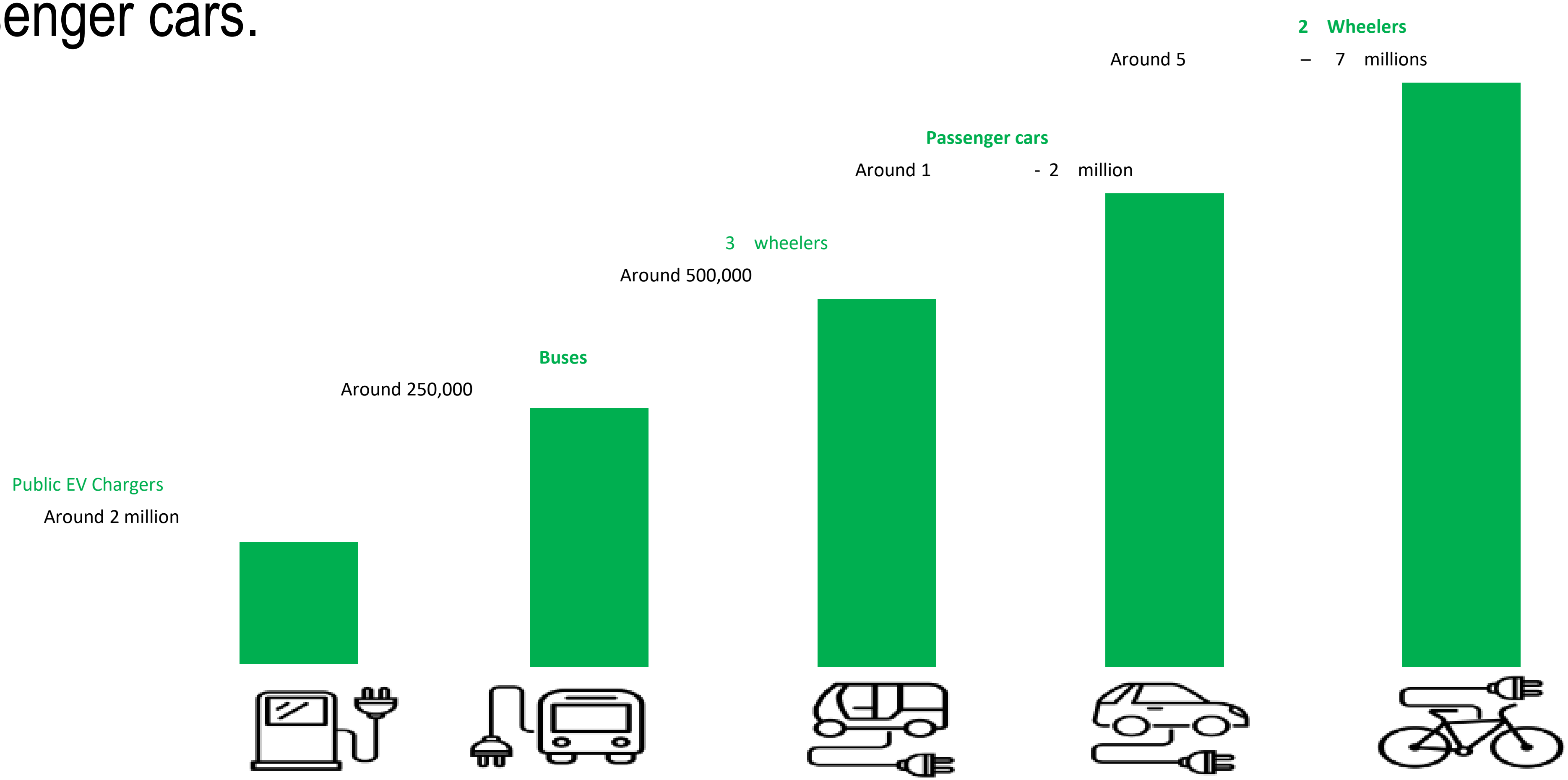
OPPORTUNITY LANDSCAPE IN EV BUSINESS IN INDIA BY 2026.

Unlike other countries, Indian EV opportunity lies in a variety of automobiles and not just passenger cars.



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BHARAT EV SPECIFICATIONS FOR AC and DC CHARGING.

Bharat EV charger AC-001

Bharat EV charge DC -001

Home charging –

The home charger or on board charger are generally used with 230V/15A single phase supply which can deliver up to 2.5 KW of power. Recommended connector type IEC 60309 for both ends.

AC Slow charging –

Slow AC charging is the most common method of charging EV's. An EVSE supply AC current to on board charger which converts it to DC allowing batteries to be charged.

Fast AC charging –

Electric cars like Nissan leaf have on board chargers capable of fast charging at 7.7 to 22 KW.

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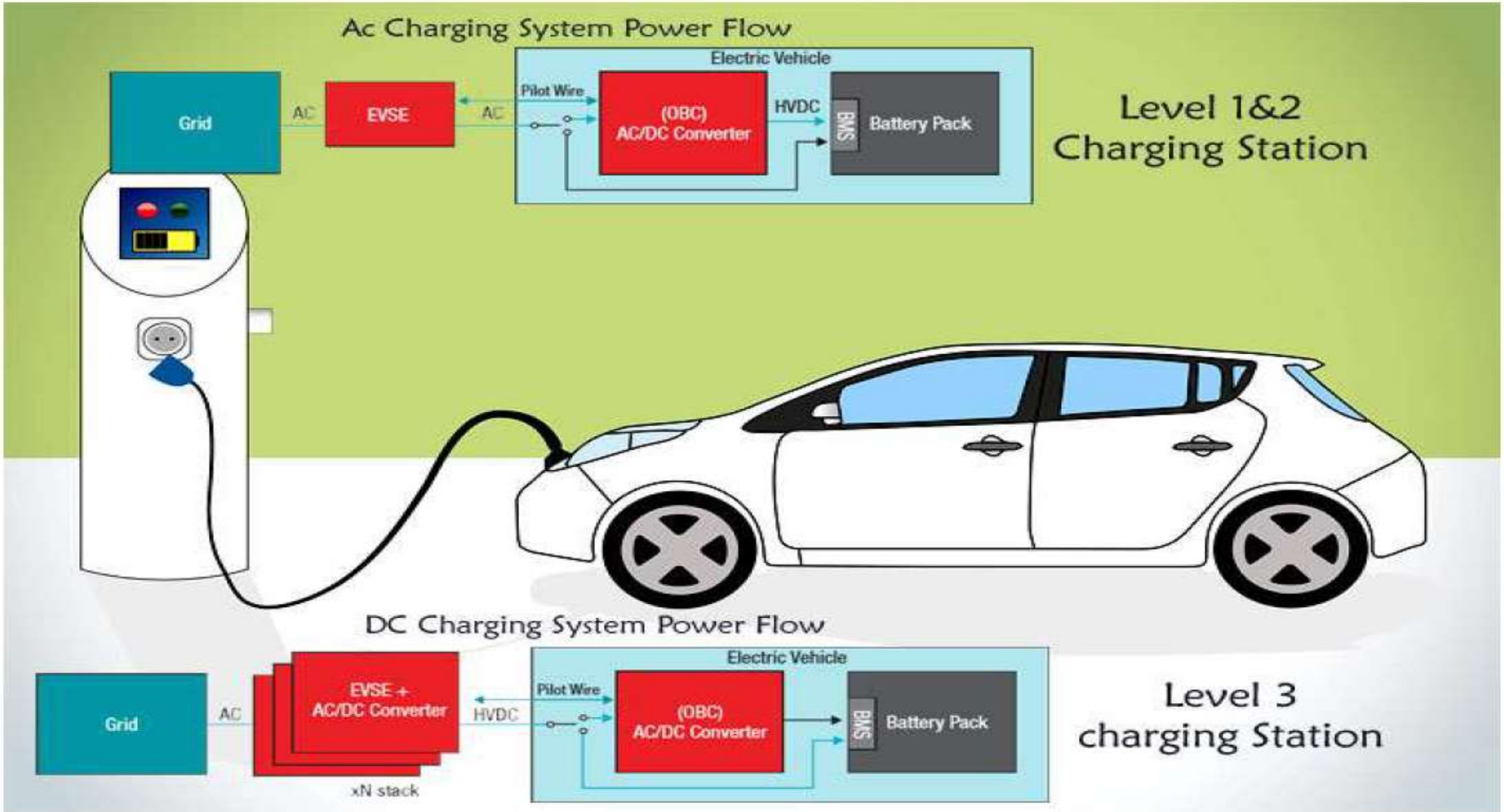

Electric Vehicle On-board Chargers and Charging Stations

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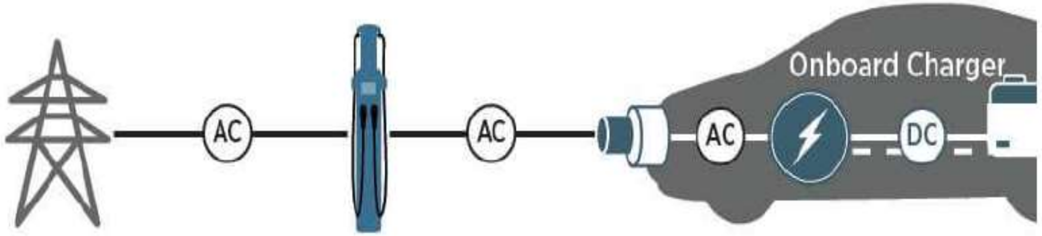
What Differentiates Level 2 (AC) and DC Fast Charging

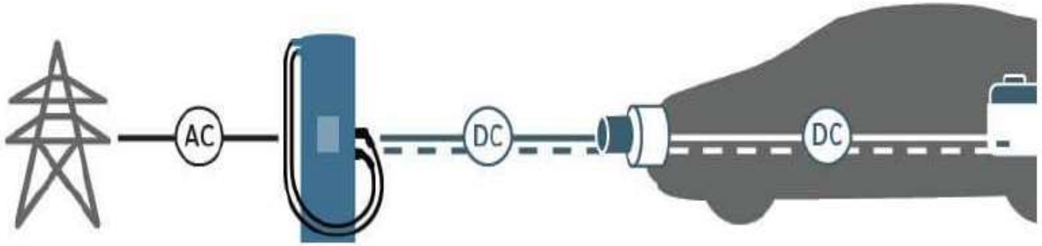
Level 2 Charging

AC power is supplied from the charging station to the on-board charger, which supplies DC power to the battery.



DC Fast Charging

The charger is off board the vehicle and supplies DC power directly to the battery.



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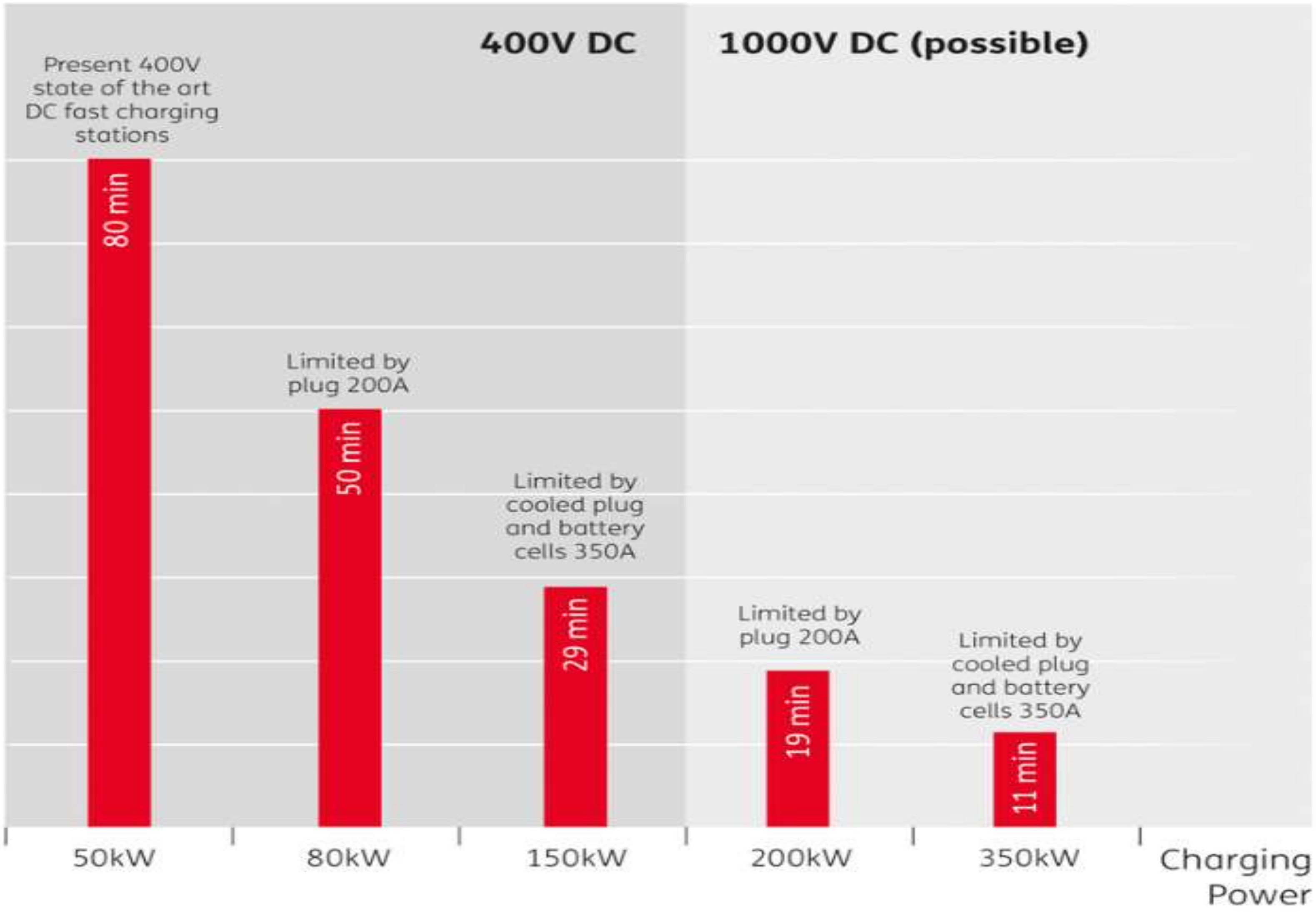
Charging time and the charging power relationship.



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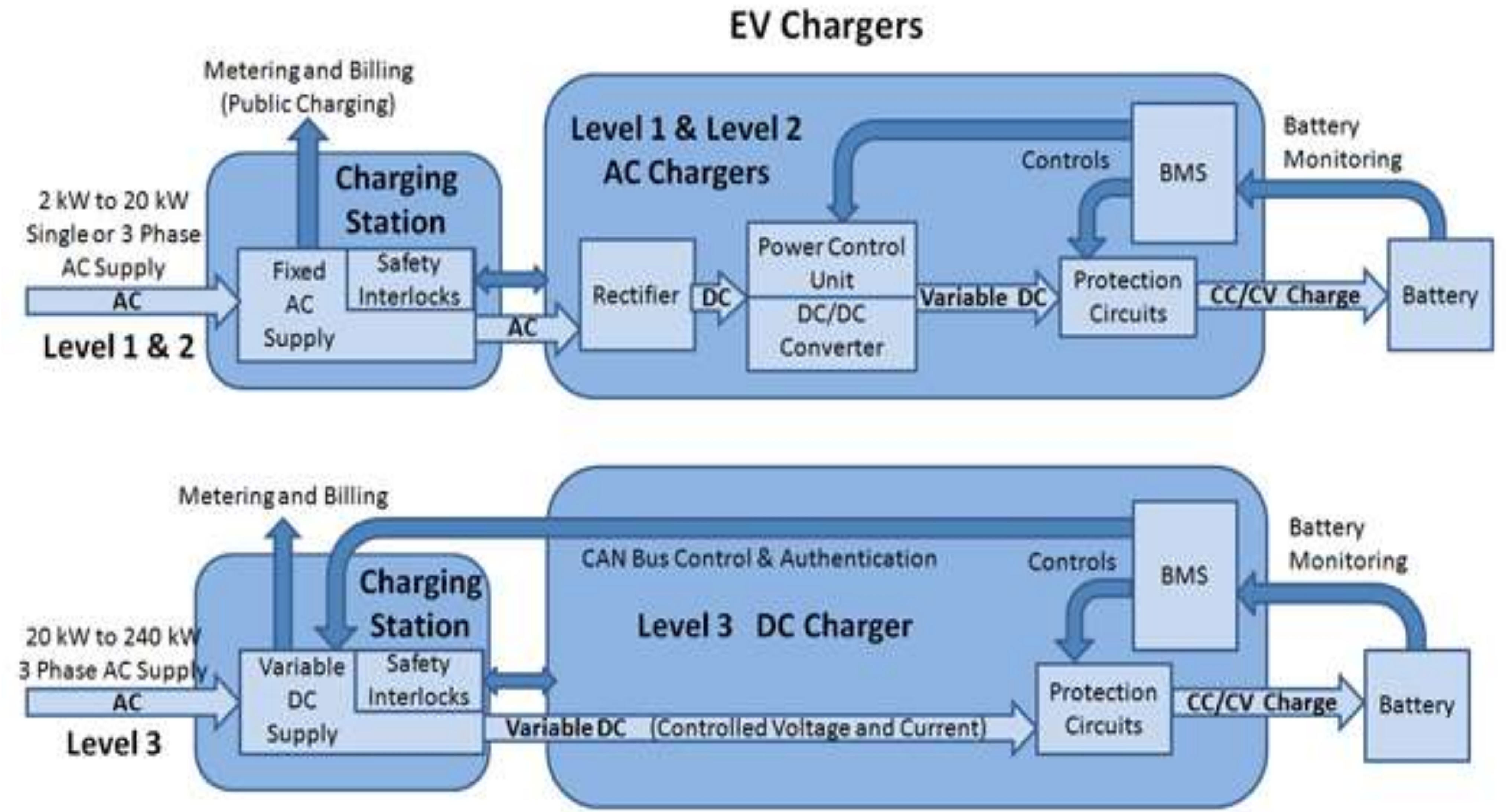

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Basic circuit diagram of a charging station with multiple DC fast charging points.

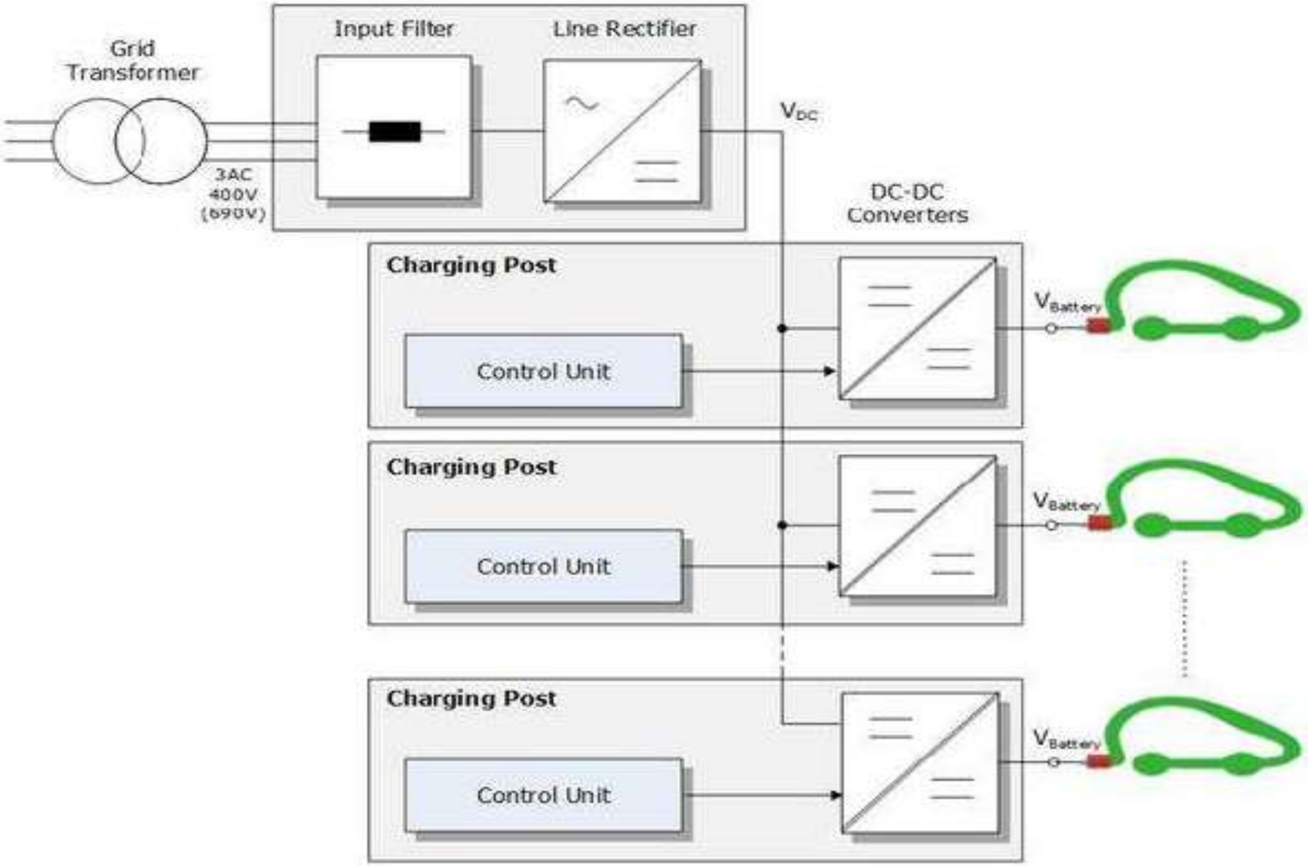

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TABLE 1. Technical specifications of commercially available dc fast chargers.

Manufacturer and Model	ABB Terra 53	Tritium Veefil-RT	Tesla Supercharger	EVTEC espresso&charge	ABB Terra HP
Rated power	50 kW	50 kW	135 kW	150 kW	350 kW
Supported standards	CCS Type 1 CHAdeMO 1.0	CCS Types 1 and 2 CHAdeMO 1.0	Supercharger	SAE Combo 1 CHAdeMO 1.0	SAE Combo 1 CHAdeMO 1.2
Input voltage	480 Vac	380–480 Vac 600–900 Vdc	200–480 Vac	400 Vac ± 10%	400 Vac ± 10%
Output dc voltage	200–500 V 50–500 V	200–500 V 50–500 V	50–410 V	170–500 V	150–920 V
Output dc current	120 A	125 A	330 A	300 A	375A
Peak efficiency (charger only)	94%	>92%	92%	93%	95%
Volume	758 L	495 L	1,047 L	1,581 L	1,894 L
Weight	880 lb (400 kg)	364 lb (165 kg)	1,320 lb (600 kg)	880 lb (400 kg)	2,954 lb (1,340 kg)

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AC Plug Connectors –

- Bharat EV specifications recommend using IEC 60309 plug. Mostly used on E rickshaws.

- IEC 62196 Type 2 connector used by Indian cars like Renault Zoe, Nissan Leaf, Mahindra e2O

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Type 2	CCS	CHAdeMO	GB/T 20234
			
AC-Charger	DC-Charger	DC-Charger	DC-Charger
U_{max} = 400 V, 3-phase	U_{max} = 850 V	U_{max} = 600 V	U_{max} = 750 V
I_{max} = 63 A	I_{max} = 200 A	I_{max} = 200 A	I_{max} = 250 A
$P_{Connector}$ = 43,5 kW	$P_{Connector}$ = 170 kW	$P_{Connector}$ = 120 kW	$P_{Connector}$ = 187,5 kW
Communication = PWM/PLC		Communication = CAN	

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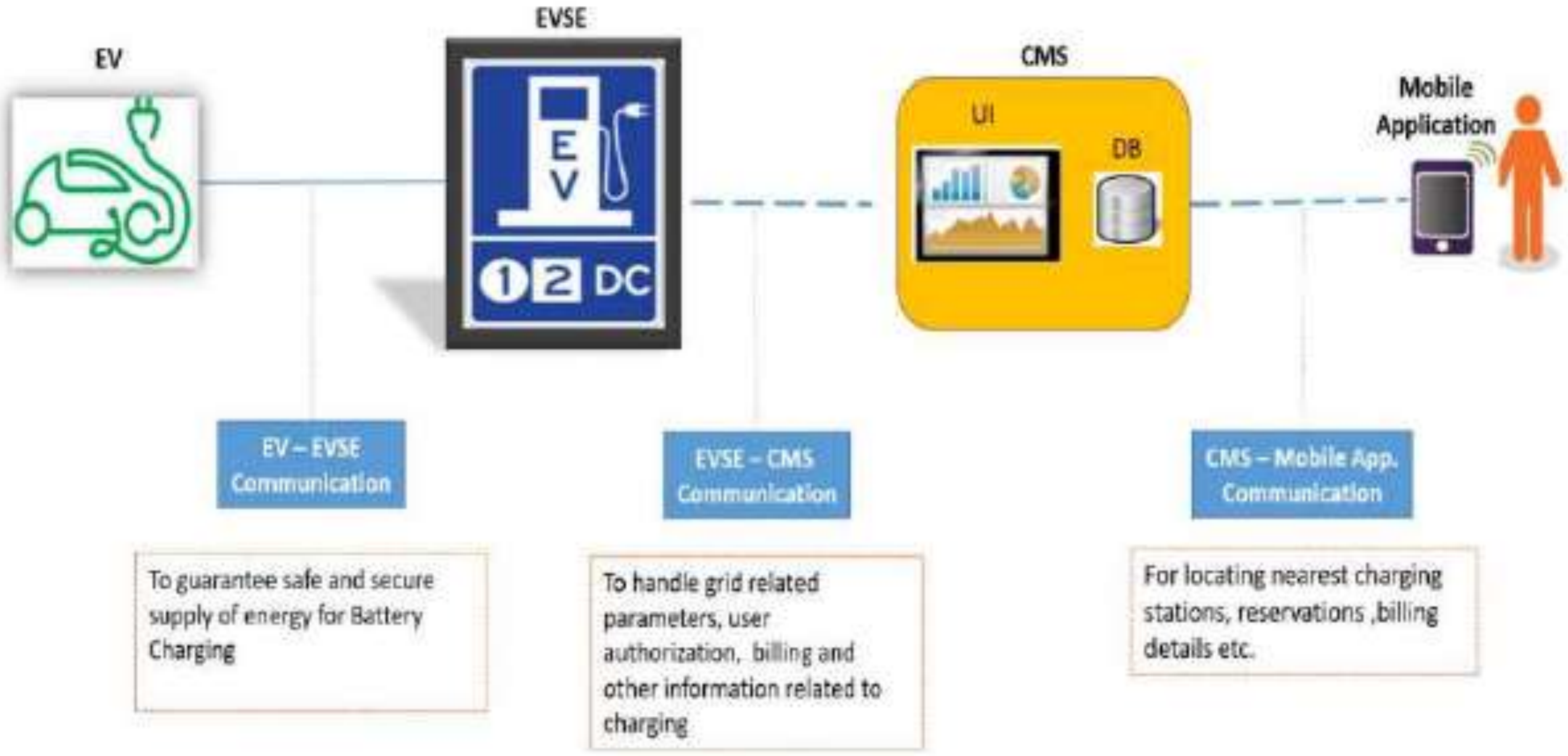
Architecture of EV and Charging infrastructure.



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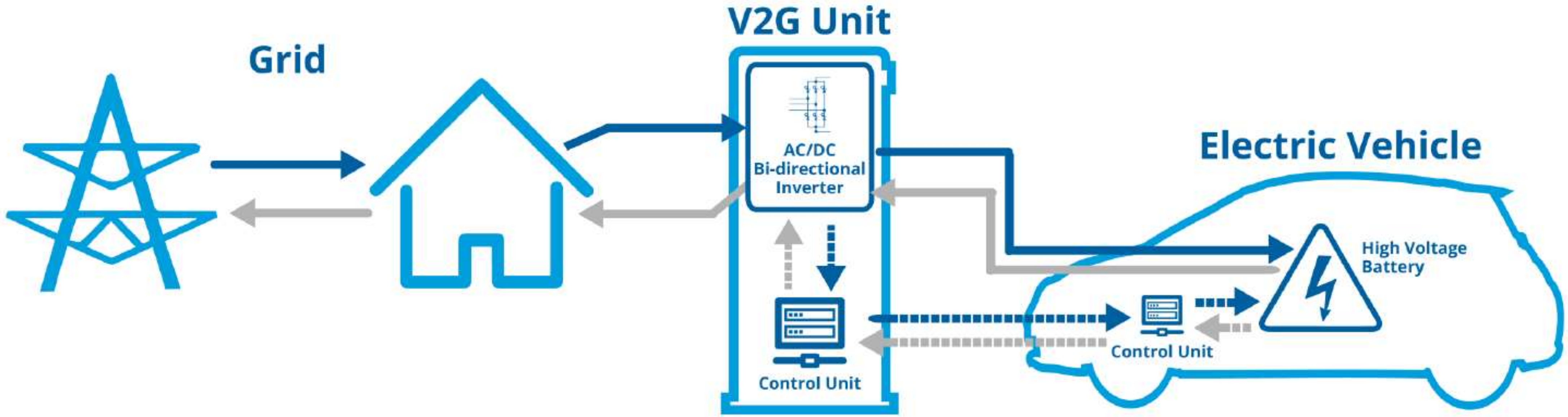
The future V2G?



- Vehicle-to-grid (V2G) describes a system in which plug-in electric vehicles, such as electric cars (BEV) and plug-in hybrids (PHEV), communicate with the power grid to sell demand response services by either returning electricity to the grid or by throttling their charging rate
- Since at any given time 95 percent of cars are parked, the batteries in electric vehicles could be used to let electricity flow from the car to the electric distribution network and back. This represents an estimated value to the utilities of up to $4,000 per year per car.

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CHARGING STANDARD DATA

Standard		Scope
IEC 61851: Conductive charging system	IEC 61851-1	Defines plugs and cables setup
	IEC 61851-23	Explains electrical safety, grid connection, harmonics, and communication architecture for DCFC station (DCFCS)
	IEC 61851-24	Describes digital communication for controlling DC charging
IEC 62196: Socket outlets, plugs, vehicle inlets and connectors	IEC 62196-1	Defines general requirements of EV connectors
	IEC 62196-2	Explains coupler classifications for different modes of charging
	IEC 62196-3	Describes inlets and connectors for DCFCS
IEC 60309: Socket outlets, plugs, and couplers	IEC 60309-1	Describes CS general requirements
	IEC 60309-2	Explains sockets and plugs sizes having different number of pins determined by current supply and number of phases, defines connector color codes according to voltage range and frequency.
IEC 60364		Explains electrical installations for buildings
SAE J1772: Conductive charging systems		Defines AC charging connectors and new Combo connector for DCFCS
SAE J2847: Communication	SAE J2847-1	Explains communication medium and criteria for connecting EV to utility for AC level 1&2 charging
	SAE J2847-2	Defines messages for DC charging
SAE J2293	SAE J2293-1	Explains total EV energy transfer system, defines requirements for EVSE for different system architectures
SAE J2344		Defines EV safety guidelines
SAE J2954: Inductive charging		Being developed

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CHRAGING LEVEL AND ITS RATING

AC Charging System	Supply Voltage (V)	Maximum Current (A)	Branch Circuit Breaker Rating (A)	Output Power Level (kW)
Level 1	120 V, 1-phase	12	15	1.08
	120 V, 1-phase	16	20	1.44
Level 2	208 to 240 V, 1-phase	16	20	3.3
	208 to 240 V, 1-phase	32	40	6.6
	208 to 240 V, 1-phase	≤80	Per NEC 635	≤14.4
Level 3	208/480/600 V	150–400	150	3

DC Charging System	DC Voltage Range (V)	Maximum Current (A)	Power (kW)
Level 1	200–450	≤80	≤36
Level 2	200–450	≤200	≤90
Level 3	200–600	≤400	≤240

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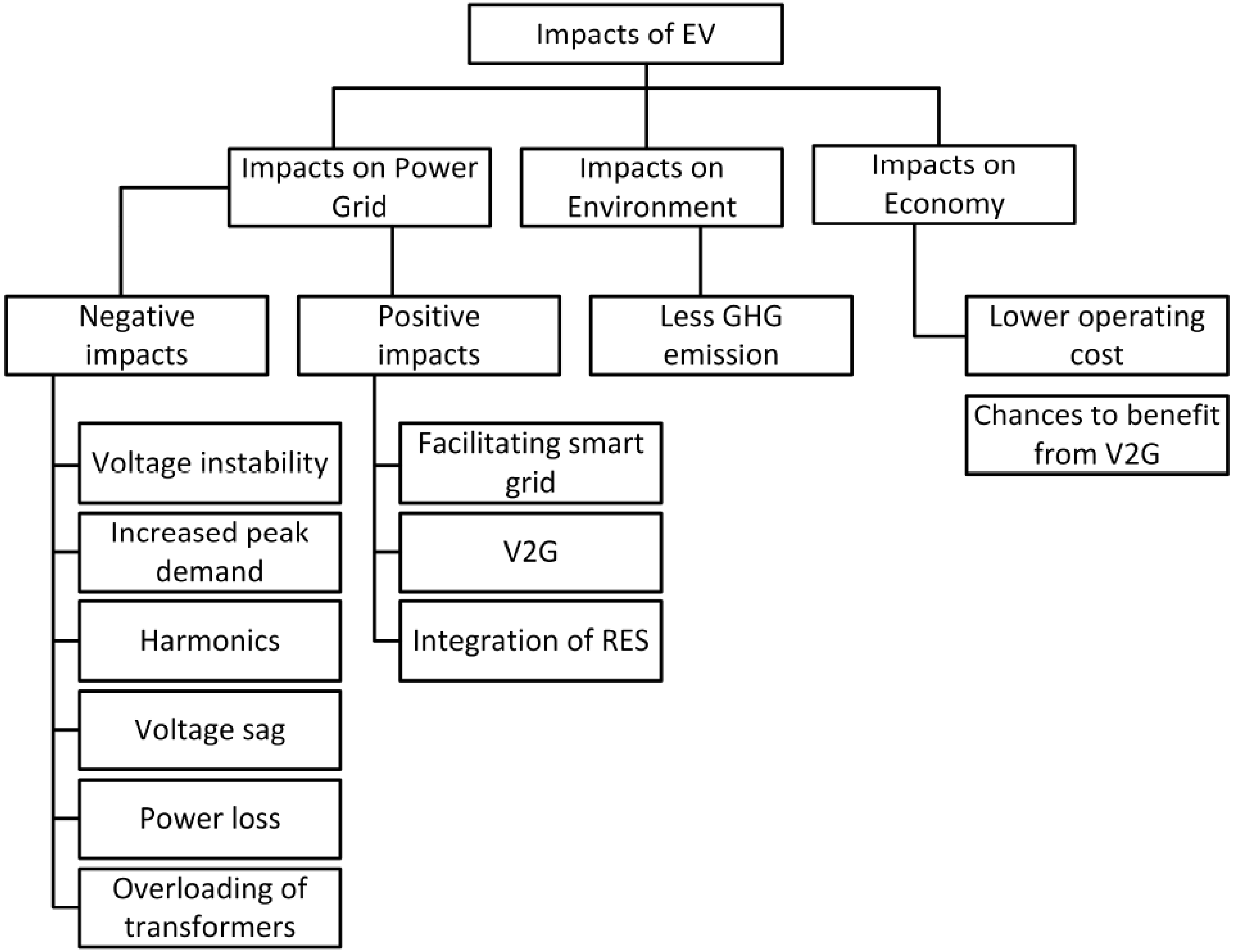
IMPACT OF EV ON POWRRGRID, ENVIRONMENT & ECONOMY.



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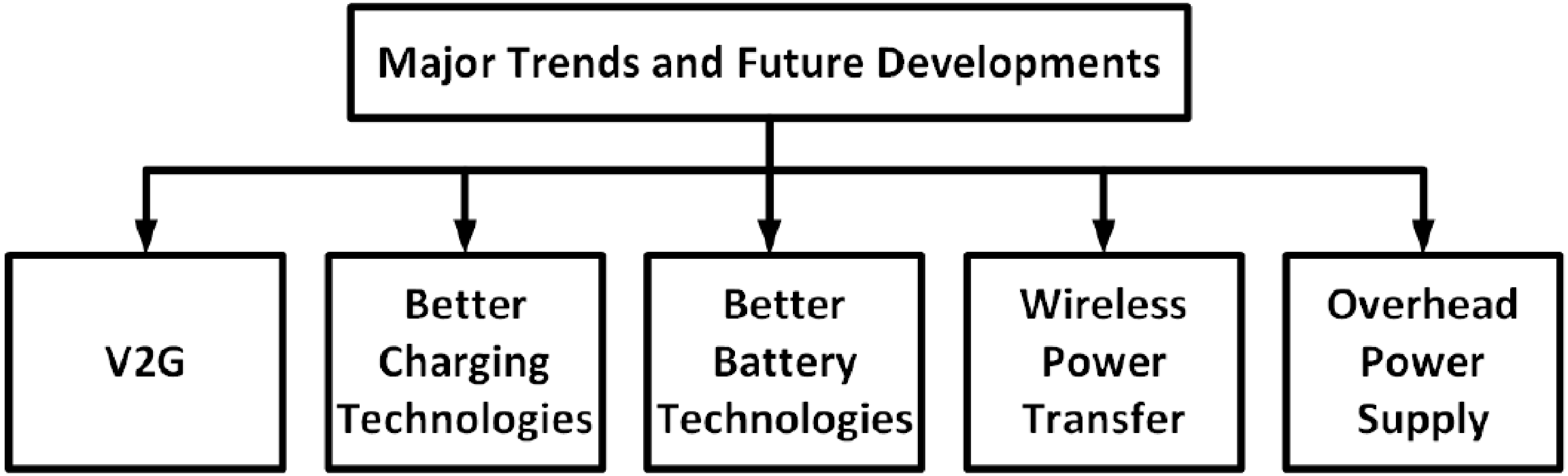
MAJOR TREND AND FUTURE DEVELOPMENTS



- Vehicle to Grid is a new trend where the energy stored in batteries is utilized by grid during the peak power demand and the batteries are charged during low demand like night time.
- Charging technology is developing at a very fast speed, now the charging rates like 350 KW rating are available. A flash charge system

Is used for commercial vehicles like city buses, which gets charged during 20 second while passengers are getting in or out.
The roads are built where during running the batteries are charged.

- Metal oxide batteries and fuel cell technology is likely to get commercial soon. With metal oxide battery the dependence on Lithium

And scares material is end. The metals which is available locally in abundance is used for power generation. For a mid size car the Range of 1000 km a kg of metal is achieved. With this technology the running expense per km is likely to as low as RS. 0.35.

- Wireless charging and overhead charging also should be available commercially in the country in near future. ABB will bring this

Technology with Ashok Leyland buses very soon.

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By 2040, 54% of new car sales and 33% of the global car fleet is predicted to be electric. More than six countries have announced a ban on internal-combustion engines.

Some of the important trends driving EV development are getting more than 200 miles out of a charge, pricing below $40,000, fast charging (such as less than 30 minutes for an 80% charge), increasing fuel efficiency over a longer range for hybrids, and developing autonomous vehicles and electrification for not just cars but also industrial, public service, and mass transportation vehicles.

For the electric powertrain, engineering focus is on the price and size of battery packs, motor efficiency that affects driving range, and the tradeoff between drive range or performance with the ever-increasing driver experience requirements and features. Energy storage needs to be designed so that it obtains the required energy and power density in each battery cell as well as the overall pack. The pack has to be thermally regulated so that it will not overheat. Energy storage has to be monitored and optimized while driving.

The motor and power electronics must be optimal for the architecture, weighing efficiency vs. performance vs. cost. Here also, thermal management and reliability are important issues. The power electronics need to be reliable over a wide range of operating temperatures, and design is a challenge with the inverter and motor inside a single casing.

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Trends in Electric vehicle design

In the year 2017 roughly 1.3 million EVs were sold globally, which makes about 1% of the total passenger vehicle sales. It was 57% increase over 2016, and the trend will continue.
Established OEMs have announced launch of over 100 new BEV models by 2024.
It is expected that 30-35% of vehicles sales in major market (20-25% globally) is achievable by 2030.
What will help EV gain market share is that OEMs have reached ranges with their EVs which allow them to focus on reducing price points, e.g., via further increasing design efficiency or reducing manufacturing cost to become affordable.
Average range of benchmarked EVs surpassed 300 KM, which has solved the issue of range enxity to majority of the owners, and OEMs seems to be able to concentrate on entering lower price segment.
Despite higher investments in the form of engineering, tooling etc. native EV platforms have proven advantageous.
Designing the vehicular architecture entirely around EV concept means fewer compromises and more flexibility.

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The freedom of designing a body structure around battery pack allows the use of larger capacity battery packs, which gives the advantages like higher range, more power, faster charging and reduction in unnecessary extra cabling etc.

BATTERY – NON NATIVE EV

BATTERY – NATIVE EV

The flexibility and Battery pack and variable drive train technology allows to produce rear-wheel, front wheel, and all wheel drive on a single platform..

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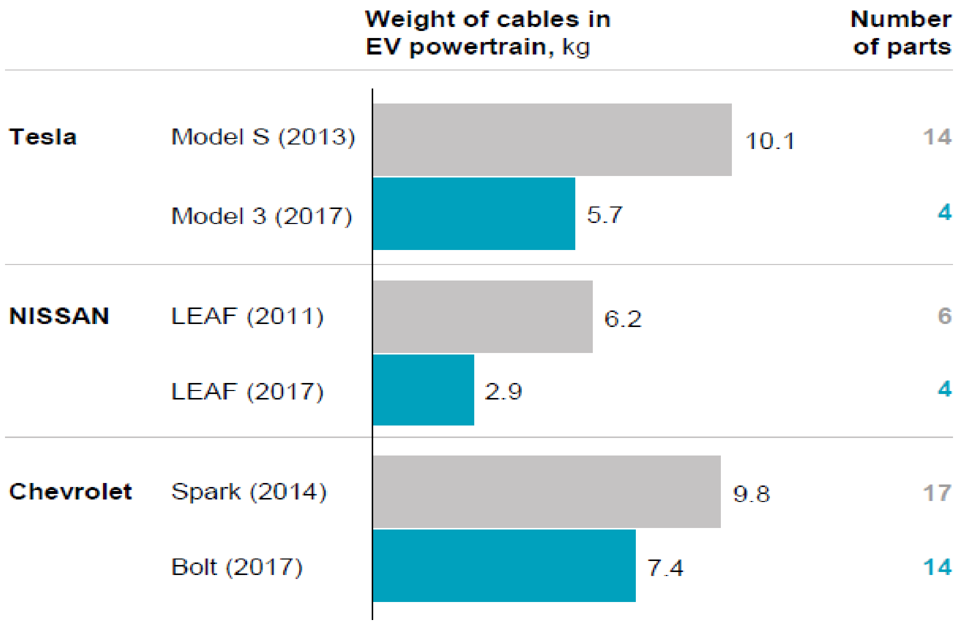
EV POWERTRAIN INTEGRATION.

EV powertrain integration is a continued trend for couple of years, with many power electronics moving closer together and being integrated into a fewer modules. There is no standard EV powertrain design as at now.

A good indicator of increased level of integration is the design of electric cables connecting the main EV powertrain components. The reduction in cable weight and number of parts compared to earlier models reflects the higher integration of powertrain systems.



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Automobile manufacturers are forced to give lot of add on to the basic vehicle, which improves the driving comforts. With increased add on the vehicles with advanced driver assistance systems ADAS connectivity, a highest level of technology, redefining the travel strategies. The self drive car is the best example of these add on and new technology implementation.

The use of artificial intelligence and IOT is increasing day by day in automotive sector.

OEMs are meeting the needs of EV customers by enhancing the user interface and infotainment systems. Specifically they are integrating the controls of a wide range of interior functions into a more central, “smart phone” like user interface.

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EV DESIGN

EV design is a complex subject where in the different type of components need to be design and integrated for effective and efficient performance.

Communication at a very high speed between different components is very important for satisfactory performance of a system.

EV Design considerations are same as of general automobile with little difference in subsystems.

Main steps in EV designing are ---

- EV Technical specifications.
- Subsystem technical specifications.
- Component technical specifications.
- Design to cost consideration.
- Time frame for development.

EV technical specification include the specifications like –

Body mass, Rolling resistance, Transmission efficiency, Aerodynamic considerations, chassis and body design etc.

Subsystem are the areas like traction motor & Controller design, Battery & BMS design, Transmission & mounting design, Human Machine interface design etc.

Component design is the designing of individual component to match the performance required. Individual components like motor, battery etc are covered in this area.

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There are a lot of variables need to consider while designing the individual component.

Some of the important factors that need to consider while designing EV components like motor, battery, transmission etc. are listed here below –

- Gross vehicle weight – determines energy required to travel a KM of distance.
- Diameter of the tyres – Determines the no of rotation required on wheel to achieve the required speed
- Energy required to move the standing vehicle – Determines the torque required from transmission system on wheel.
- Maximum speed required – Determines the maximum reduction on transmission and RPM required on motor.
- Acceleration time required – Determines the transmission gear ratios.
- Range required – Determines the battery capacity required.
- Charging and discharging requirement etc. – Determines the battery chemistry required.

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Designing of components is a very critical and complex process that needs a detailed study of the requirements from the component/subsystem, understanding the harsh working conditions, communication and integration with other vehicular systems.

While designing a best suited product one has to keep the balance of the quality, cost and time to commercialize the design. Design to cost is one of the very important consideration specially in Indian market as the consumers are very cost conscious. The market is still in a very infant stage, the proven indigenous systems and components are not yet available. The market till recent was completely depending upon the import mainly from China, due to cost consideration. The local manufacturing was not developed due to the cost consideration. Regret to say that the industry as a whole did not put required investments in local R & D and manufacturing.

The initial Electric vehicles supplied by both the manufacturer were by way of value addition in assembly of CKD components.

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We list here below the points need to consider while designing a Battery pack.

1) End use of battery pack – Application vehicle/storage
2) Cell type – Chemistry of the cell like Lithium LFP/NMC/LTO
3) Battery system design energy – KWH @100 DOD
4) Usable energy – KWH @ 80% DOD
5) Battery system – voltage and AH rating
6) Battery pack charging power (Continuous and Peak) – KW
7) Battery pack discharge power (Continuous and Peak) – KW
8) Self discharge rate,
9) Abuse test – Over charge, Over dis-charge, short etc.
10) Life expectancy of battery – no of cycles/Years
11) Motor peak power – KW
12) Working voltage range – V

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13) Nominal Voltage – V
14) Cell module – Ah, no
15) Module quantity – No
16) Cell capacity – AH
17) Module capacity – AH
18) Pack capacity – AH
19) Battery pack – Voltage and connection
20) Usage environmental conditions – Charging / discharging temperature, Humidity etc.
21) Heating requirement & method – Yes/NO, Film/Fluid etc.
22) Cooling requirement – YES/NO, Air cooling/Liquid cooling
23) Is the cooling is shared with other equipment like motor – Yes/NO
24) Coolant circulation provision in Vehicle – Yes/NO
25) Coolant connector preference if any
26) Desired coolant pressure and flow requirements
27) Coolant to be used
28) Preferred USB to CAN diagnostic tool – Yes/NO

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29) No. of CAN channels required
30) Preferred CAN protocol (eg. OBD, UDS, Open CAN etc)
31) Charging C rate
32) Charging rating KW
33) Regenerative charging requirement – Yes/NO
34) Charging pattern – Cycle use (Charge/ Discharge not simultaneous)
35) Communication interface used
36) Communication protocol requirement
37) Data required for monitoring (Remaining time, Error, Voltage, Temperature, Time, Currant etc)
38) Charger communication protocol
39) Onboard vehicle charger present – Yes/NO
40) Connector specification/preference for HV and LV
41) No. of CAN channels required
42) Preferred CAN protocol (eg. OBD, UDS, Open CAN etc)
43) Charging C rate

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44) Any presence of heat source in close proximity of battery pack location
45) Design verification testing requirements
46) Proto type development timeline
47) Packaging requirement and transportation standard compliance.

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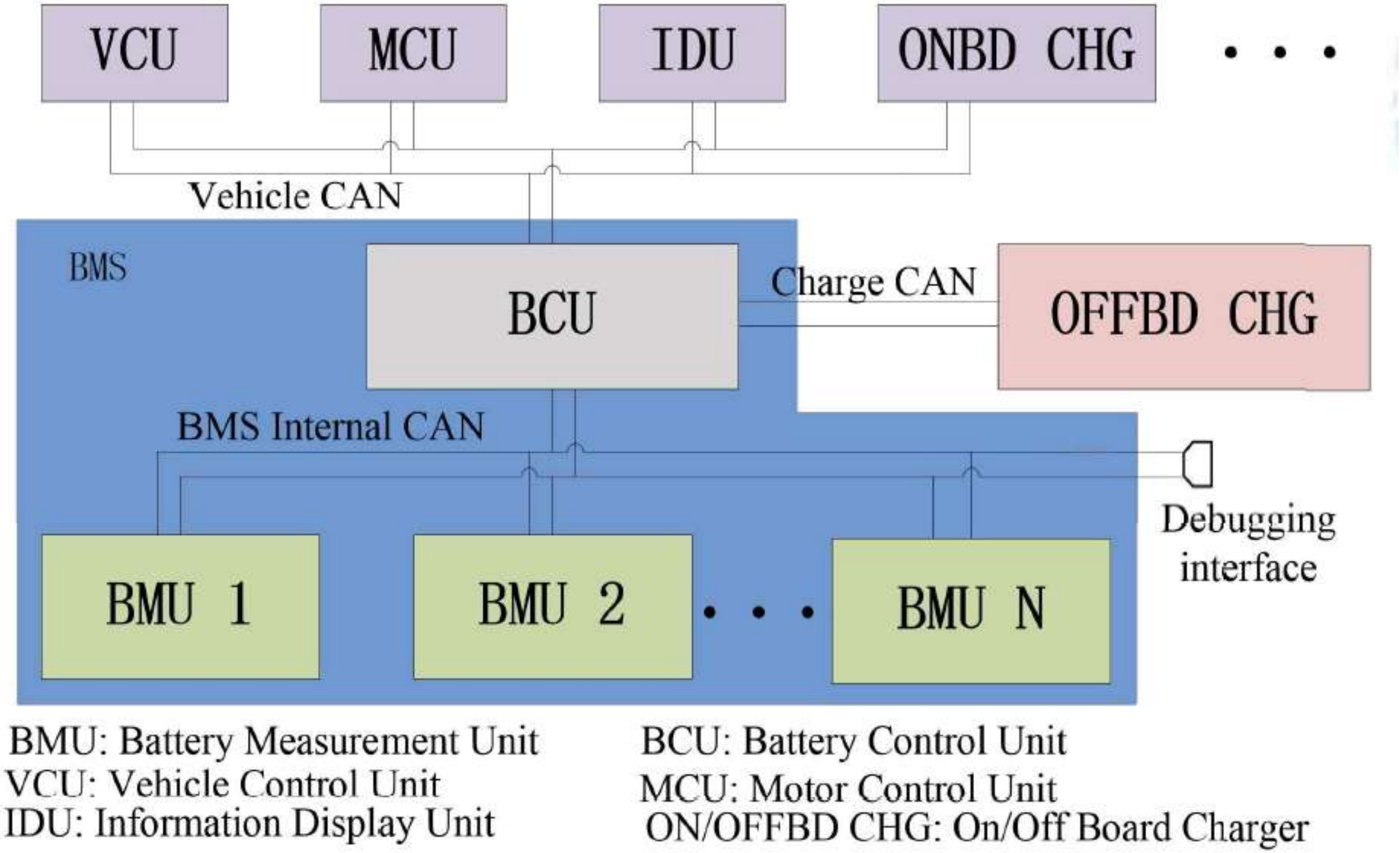
BMS AND ITS COMMUNICATION WITH OTHER SUBSYSTEMS.



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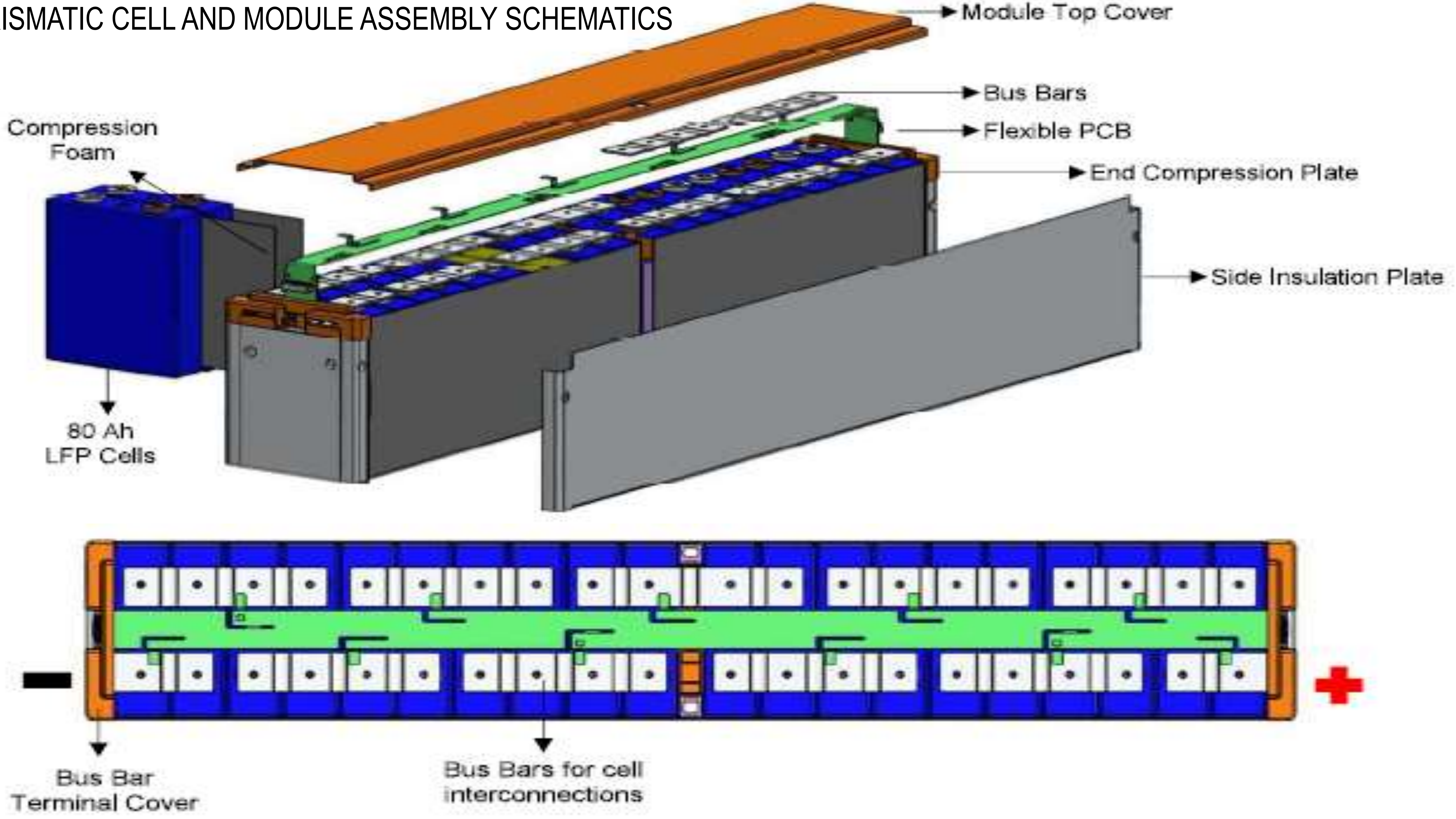
PRISMATIC CELL AND MODULE ASSEMBLY SCHEMATICS



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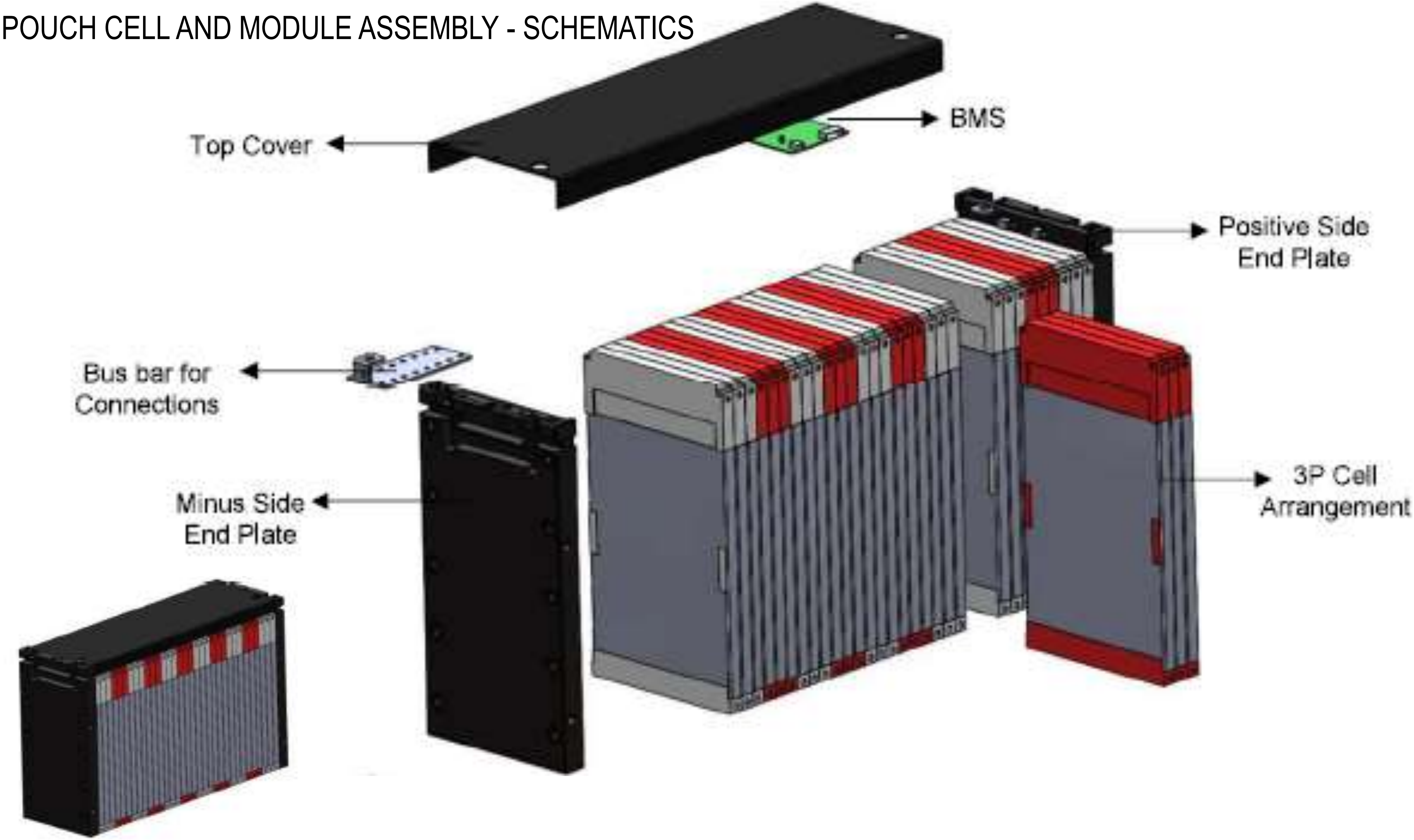
POUCH CELL AND MODULE ASSEMBLY - SCHEMATICS



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